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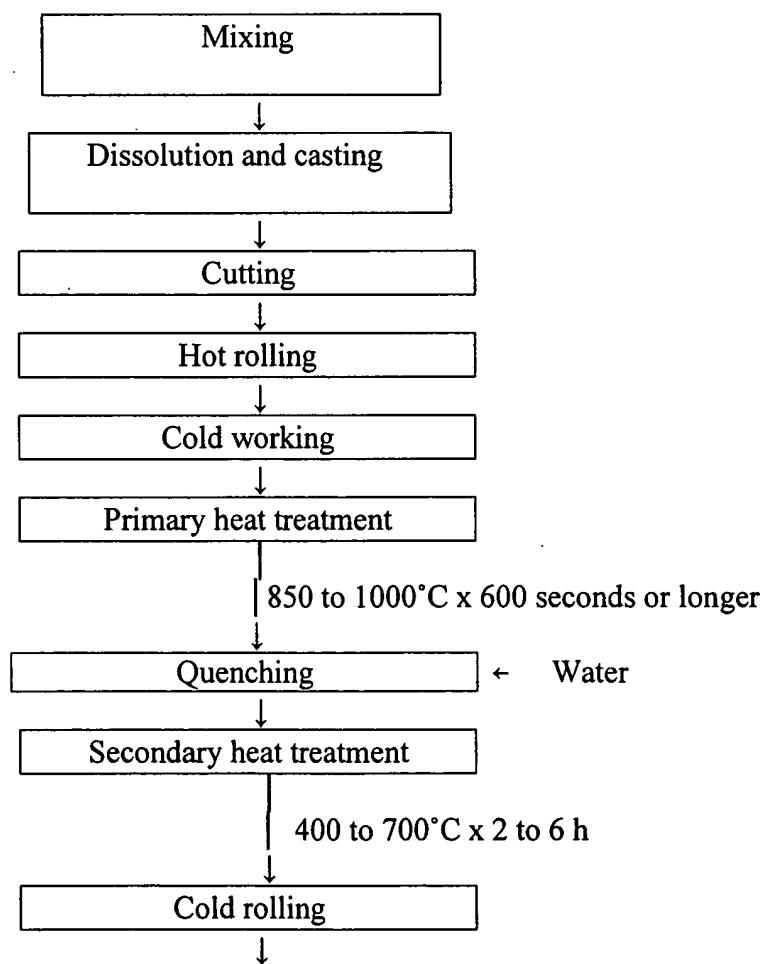
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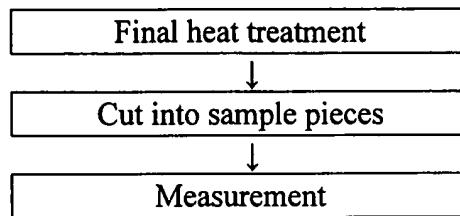
(54) [Title of the Invention] Copper Alloy for Lead Frame and
Method for Producing the Same

(57) [Abstract]

[Problem] To provide a copper alloy for a lead frame that has excellent mechanical strength, conductivity, heat resistance properties, and direct bondability; is inexpensive; and is an ideal lead frame material, as well as a method for producing the same.

[Means for Solving Problem] A high-strength conductive copper alloy that comprises, by weight ratio, 0.05 to 0.3% Ag, 0.05 to 0.3% Cr, less than 0.0010% P, and less than 0.0010% Sn, with the remainder being essentially Cu and inevitable impurities; a copper alloy for a lead frame that comprises in addition to the above-mentioned components, a total of 0.01 to 0.3% of one or more elements selected from Zn, Ni, Mg, Zr, Ti, and Al; and a method for producing a copper alloy for a lead frame, characterized in that these copper alloys are cast, hot rolled, cold worked, heat treated at 850 to 1,000°C for 600 seconds or longer, quenched with water, held within a temperature range of 400 to 700°C for 2 to 6 hours, cold rolled at 70% or greater, and subjected to a final heat treatment.





[Claims]

[Claim 1] A copper alloy for a lead frame, characterized in that it comprises, by weight ratio, 0.05 to 0.3% Ag, 0.05 to 0.3% Cr, less than 0.0010% P, and less than 0.0010% Sn, with the remainder consisting essentially of Cu and inevitable impurities.

[Claim 2] A copper alloy for a lead frame, characterized in that it comprises, by weight ratio, 0.05 to 0.3% Ag, 0.05 to 0.3% Cr, less than 0.0010% P, less than 0.0010% Sn, and a total of 0.01 to 0.3% of one or more elements selected from Zn, Ni, Mg, Zr, Ti, and Al, with the remainder consisting essentially of Cu and inevitable impurities.

[Claim 3] A method for producing a copper alloy for a lead frame, characterized in that a copper alloy that comprises, by weight ratio, 0.05 to 0.3% Ag, 0.05 to 0.3% Cr, less than 0.0010% P, and less than 0.0010% Sn, with the remainder consisting essentially of Cu and inevitable impurities, is cast, hot rolled, cold worked, heat treated at 850 to 1,000°C for 600 seconds or longer, quenched with water, held within a temperature range of 400 to 700°C for 2 to 6 hours, cold rolled at 70% or greater, and subjected to a final heat treatment.

[Claim 4] A method for producing a copper alloy for a lead frame, characterized in that a copper alloy that comprises, by weight ratio, 0.05 to 0.3% Ag, 0.05 to 0.3% Cr, less than 0.0010% P, less than 0.0010% Sn, and a total of 0.01 to 0.3% of one or more elements selected from Zn, Ni, Mg, Zr, Ti, and Al, with the remainder consisting essentially of Cu and inevitable impurities, is cast, hot rolled, cold worked, heat treated at 850 to 1,000°C for 600 seconds or longer, quenched with water, held within a temperature range of 400 to 700°C for 2 to 6 hours, cold rolled at 70% or greater, and subjected to a final heat treatment.

[Detailed Description of Invention]

[0001]

[Technical Field of the Invention] The present invention relates to a copper alloy for a lead frame that is ideal as a lead frame material as well as a method for producing the same.

[0002]

[Prior Art] Copper alloys such as oxygen-free copper, Sn copper, and Fe copper are widely known as conventional copper alloys for lead frames.

[0003] As a result of the miniaturization and reduction in weight of electronic equipment, such lead frame materials must not only have excellent mechanical properties, but also the following properties:

- (1) excellent electrical and thermal conductivity,
- (2) excellent resistance to softening,
- (3) excellent moldability, and
- (4) excellent direct bondability.

Nevertheless, it cannot be said that such properties are satisfied by the various conventional copper alloys.

[0004]

[Problem to be Solved by the Invention]

The present invention provides a copper alloy for a lead frame that has the excellent moldability, electrical conductivity, heat resistance properties, and direct bondability required of lead frame materials.

[0005]

[Means for Solving Problems]

The first [subject of the] invention is a copper alloy for a lead frame, characterized in that it comprises, by weight ratio, 0.05 to 0.3% Ag, 0.05 to 0.3% Cr, less than 0.0010% P, and less than 0.0010% Sn, with the remainder consisting essentially of Cu and inevitable impurities;

[0006] The second [subject of the] invention is a copper alloy for a lead frame, characterized in that it comprises, by weight ratio, 0.05 to 0.3% Ag, 0.05 to 0.3% Cr, less than 0.0010% P, less than 0.0010% Sn; and a total of 0.01 to 0.3% of one or more elements selected from Zn, Ni, Mg, Zr, Ti, and Al, with the remainder consisting essentially of Cu and inevitable impurities;

[0007] The third [subject of the] invention is a method for producing a copper alloy for a lead frame, characterized in that a copper alloy that comprises, by weight ratio, 0.05 to 0.3% Ag, 0.05 to 0.3% Cr, less than 0.0010% P, and less than 0.0010% Sn, with the remainder consisting essentially of Cu and inevitable impurities, is cast, hot rolled, cold worked, heat treated at 850 to 1,000°C for 600 seconds or longer, quenched with water, held within a temperature range of 400 to 700°C for 2 to 6 hours, cold rolled at 70% or greater, and subjected to a final heat treatment; and

[0008] The fourth [subject of the] invention is a method for producing a copper alloy for a lead frame, characterized in that a copper alloy that comprises, by weight ratio, 0.05 to 0.3% Ag, 0.05 to 0.3% Cr, less than 0.0010% P, less than 0.0010% Sn, and a total of 0.01 to 0.3% of one or more elements selected from Zn, Ni, Mg, Zr, Ti, and Al, with the remainder consisting essentially of Cu and inevitable impurities, is cast, hot rolled, cold worked, heat treated at 850 to 1,000°C for 600 seconds or longer, quenched with

water, held within a temperature range of 400 to 700°C for 2 to 6 hours, cold rolled at 70% or greater, and subjected to a final heat treatment.

[0009] The present invention is a copper alloy designed as described above, has excellent electrical conductivity, heat resistance, moldability, and direct bondability, and is ideal as a lead frame material.

[0010] The reasons for adding these alloy components and the reasons for restricting these components that constitute the alloy of the present invention will now be described. 0.05 to 0.3 wt% Ag is added because Ag is an added element that will not reduce the electrical conductivity of Cu and will improve strength, even when in a solid-solution state. If less than 0.05 wt% Ag is added, the effect of the Ag will be diminished, while adding more than 3 wt% is not industrially [efficient] because this effect will become saturated and adding more will raise cost.

[0011] Cr is an added element that will not reduce the electrical conductivity of Cu due to the effect of precipitation but will increase heat resistance and mechanical strength. If less than 0.05 wt% Cr is added, the effect of the Cr will be diminished, while a reduction in casting performance and electrical conductivity is unavoidable if more than 0.3 wt% Cr is added.

[0012] Less than 0.0010 wt% Sn is added because when more than 0.001 wt% is added, there is a reduction in the electrical conductivity of the Cu and there is a detrimental effect on direct bondability.

[0013] Less than 0.0010 wt% P is added because when more than 0.001 wt% is added, there is a detrimental effect on direct bondability.

[0014] Moreover, one or more elements selected from Zn, Ni, Mg, Zr, Ti, and Al is added because in this way it is possible to improve mechanical strength without a large reduction in electrical conductivity. If the amount of these elements is less than 0.01 wt%, the effect of these elements will be diminished, while if the amount exceeds 0.3 wt%, there will be a large reduction in electrical conductivity.

[0015] A copper alloy having the composition according to the first or second [subjects of the] invention is heated at 850 to 1,000°C for 600 seconds or longer in order to eliminate the precipitate that forms during production and to uniformly form a solid solution in a Cu matrix. This effect is insufficient if the heating temperature is less than 850°C, and there is a chance that some of the material will melt at a temperature higher than 1,000°C. The alloy is held at this temperature for 600 seconds or longer because the above-mentioned effects will not be obtained if this time is shorter.

[0016] Heat treatment at 400 to 700°C is employed for the uniform precipitation of the Cr once a uniform solid solution has been formed. If heat treatment is performed at a temperature lower than 400°C, sufficient precipitation will not proceed, while if the temperature is higher than 700°C, the precipitate will aggregate. The alloy is held at this temperature for 2 to 6 hours because sufficient precipitation will not proceed if the time is shorter than 2 hours, while the precipitate will aggregate if the time is longer than 6 hours.

[0017] Cold working at 70% or more is performed in order to improve mechanical strength. The final heat treatment is for alleviating the strain that is produced by cold working and recovery of elongation. Embodiments of the present invention will now be described.

[0018]

[Embodiments of the Invention]

Working Example 1

Figure 1 is a diagram showing the steps involved in making an alloy test piece of the present invention. Alloys with the compositions shown in Table 1 (first [subject of the] invention: No. 1 through No. 3, No. 7; second [subject of the] invention: No. 4 through No. 6) were melted in a high-frequency vacuum melting furnace and cast into 40 mm (width) x 100 mm (length) x 10 mm (thickness) ingots. The ingots were hot rolled at 900°C into sheets with a thickness of 10 mm and then cold worked. The sheets were heat treated at 850 to 1000°C for 600 seconds or longer (primary heat treatment) and then quenched with water.

[0019] Heat treatment (secondary heat treatment) was performed by keeping the sheets within a temperature range of 400 to 700°C for 2 to 6 hours. Then the product was cold rolled at 70% or greater to obtain sheets with a thickness of 0.25 mm. The final heat treatment was then conducted.

[0020] Samples prepared in this way were evaluated by the following tests. Mechanical strength was measured by tensile tests, elongation was measured using JIS No. 5 test pieces, hardness was measured using a Vicker's hardness gauge, softening resistance was found by determining the temperature when the hardness after heating for 7 minutes became 80% of the hardness after rolling, electrical conductivity and heat transfer performance were found from the conductivity (%IACS), and direct bondability was found by direct bonding of an Au wire, performing tensile tests under a load of 5 grams, and evaluating whether or not the wire peeled off, with O meaning that it did not

peel off [no exfoliate] and X meaning that it did peel off [exfoliate]. The results are shown in Table 1.

[0021]

[Table 1]

Test Results

No.	Alloy Composition (w%)					Primary heat treatment	Secondary heat treatment	Rolling reduction (%)	Tensile strength (N/mm ²)	Elongation (%)	Hardness (Hv)	Electrical conductivity (% IACS)	Softening temperature (°C)	Direct bondability		
	Ag	Cr	P	Sn	Other											
Present invention	1	0.1	0.12	less than 0.0010	less than 0.0010	—	Remainder	900 x 1800	600 x 4.0	77	426	7.0	137	95.6	455	0
	2	0.05	0.20	less than 0.0010	less than 0.0010	—	Remainder	900 x 1800	600 x 4.0	73	410	7.4	124	98.0	470	0
	3	0.07	0.20	less than 0.0010	less than 0.0010	—	Remainder	900 x 1800	600 x 4.0	76	415	7.2	128	92.6	465	0
	4	0.07	0.15	less than 0.0010	less than 0.0010	Zr: 0.02	Remainder	900 x 1800	600 x 4.0	75	415	7.2	130	95.1	455	0
	5	0.10	0.05	less than 0.0010	less than 0.0010	Ti: 0.01	Remainder	900 x 1800	600 x 4.0	79	428	6.8	142	96.3	450	0
Comparative Examples	6	0.05	0.17	less than 0.0010	less than 0.0010	Zn: 0.05	Remainder	900 x 1800	600 x 4.0	73	420	7.6	133	92.2	450	0
	7	0.3	0.11	less than 0.0010	less than 0.0010	—	Remainder	900 x 1800	600 x 4.0	75	412	7.6	128	96.3	455	0
	8	0.10	0.10	0.01	less than 0.0010	Zn: 0.01	Remainder	900 x 1800	600 x 4.0	70	406	7.8	124	92.0	400	X
	9	0.10	0.13	less than 0.0010	0.01	—	Remainder	900 x 1800	600 x 4.0	74	410	7.2	126	88.3	420	X
	10	0.01	0.11	less than 0.0010	less than 0.0010	—	Remainder	900 x 1800	600 x 4.0	78	394	7.0	118*	92.0	420	0

11	0.10	0.03	less than 0.0010	less than 0.0010	--	Remainder	900 x 1800	600 x 4.0	75	400	7.2	119	93.4	390	0
12	less than 0.003	0.12	0.006	less than 0.0010	--	Remainder	900 x 1800	600 x 4.0	80	418	6.8	132	91.0	410	x
13	less than 0.003	0.30	0.002	0.1	Mg: 0.01	Remainder	900 x 1800	600 x 4.0	73	410	7.4	126	89.8	400	x
14	0.06	0.45	0.013	less than 0.0010	Ni: 0.03 Al: 0.04	Remainder	900 x 1800	600 x 4.0	72	417	7.2	129	87.7	440	x
15	0.01	0.3	less than 0.0010	less than 0.0010	Zr: 0.15 Zn: 0.15 Mg: 0.012 Ti: 0.06	Remainder	900 x 1800	600 x 4.0	74	421	7.0	132	85.7	445	x
16	0.13	0.43	0.12	0.1	Zr: 0.19 Zn: 0.22	Remainder	900 x 1800	600 x 4.0	74	419	7.2	130	86.5	435	x

*Somewhat illegible—Trans. note.

[0022] The comparative materials in Table 1 are outside the composition ranges specified in the first and second [subjects of the] invention. For instance, the P in No. 8, Sn in No. 9, Ag in No. 10, Cr in No. 11, Ag and P in No. 12, Ag, P, and Sn in No. 13, Cr and P in No. 14, Ag and other components in No. 15, and other components in No. 16 are all outside the range of the composition of the present invention.

[0023] As shown in Table 1, the alloy of the present invention clearly has sufficient mechanical strength, conductivity, heat resistance, and direct bondability, and it is obvious that it is ideal as a member for electrical and electronic equipment requiring high reliability, particularly lead frame materials.

[0024] Working Example 2

Comparative production tests were conducted by the method for producing the alloy within the composition range of the present invention using production conditions within and outside the condition ranges specified by the third and fourth [subjects of the] invention. The results are shown in Table 2.

[0025]

[Table 2]

	No.	Alloy Composition (wt%)					Primary heat treatment	Secondary heat treatment	Rolling reduction (%)	Tensile strength (N/mm ²)	Elongation (%)	Hardness (Hv)	Electrical conductivity (% IACS)	Softening temperature (°C)	Direct bondability	
		Ag	Cr	P	Sn	Other										
Present invention	17	0.07	0.21	less than 0.0010	less than 0.0010	--	Remainder	900 x 1800	500 x 6.0	75	416	7.8	180	92.5	465	0
	18	0.07	0.15	less than 0.0010	less than 0.0010	Zr: 0.02 Ni: 0.04 Al: 0.01	Remainder	950 x 720	600 x 4.0	75	411	7.2	127	92.4	470	0
	19	0.10	0.06	less than 0.0010	less than 0.0010	Ti: 0.01 Mg: 0.02	Remainder	950 x 720	550 x 6.5	75	413	6.8	128	92.0	480*	0
	20	0.05	0.17	less than 0.0010	less than 0.0010	Zn: 0.05	Remainder	950 x 1800	650 x 3.0	83	410	7.0	127	94.1	480*	0
	21	0.3	0.09	less than 0.0010	less than 0.0010	--	Remainder	950 x 720	550 x 6.0	76	413	7.2	130	93.4	480	0
Comparative method	22	0.07	0.21	less than 0.0010	less than 0.0010	--	Remainder	970 x 432	600 x 4.0	70	406	7.0	126	88.7	400	0
	23	0.07	0.15	less than 0.0010	less than 0.0010	Zr: 0.02 Ni: 0.04 Al: 0.41	Remainder	900 x 1800	750 x 2.0	75	389	7.2	110	91.8	370	0
	24	0.10	0.05	less than 0.0010	less than 0.0010	Ti: 0.01 Mg: 0.02	Remainder	950 x 720	400 x 7.0	65	413	7.6	126	85.3	420	X
	25	0.05	0.17	less than 0.0010	less than 0.0010	Zn: 0.05	Remainder	800 x 3600	600 x 4.0	79	418	7.4	129	88.4	390	X

*somewhat illegible—Trans. note.

[0026] The alloy compositions in Table 2 for Nos. 17 and No. 22 are the same as No. 3 in Table 1, those for No. 18 and No. 23 are the same as No. 4 in Table 1, those for No. 19 and No. 24 are the same as No. 5 in Table 1, and those for No. 20 and No. 25 are the same as No. 6 in Table 1. The production conditions, particularly those for primary heat treatment, have been changed. As in Working Example 1, the steps involved in producing the test pieces are shown in Figure 1.

[0027] As is clear from Table 2, Nos. 17, 18, 19, and 20, which are within the composition range and the production condition range specified by the present invention, have the same excellent mechanical strength, conductivity, heat resistance, and direct bondability as Nos. 3, 4, 5, and 6 of Working Example 1 (shown in Table 1), but alloy Nos. 22 and 25, which were made under different primary heating conditions, and Nos. 23 and 24, which were made under different secondary heat treatment conditions, have particularly poor conductivity and direct bondability.

[0028]

[Effect of the Invention] As is clear from the above-mentioned working examples, the copper alloy and the method for producing the same of the present invention provide the alloy with excellent moldability, mechanical strength, conductivity, heat resistance, and direct bondability, and this alloy is ideal for electrical and electronic components requiring high reliability, particularly lead frame materials,.

[0029] Moreover, the alloy of the present invention can be produced more simply and less expensively than a copper base alloy requiring special heat treatment and

complex processes without any technical difficulties, because melting, hot rolling, cold rolling, intermediate heat treatment, and similar procedures are very easy techniques.

[Brief Description of the Drawings]

[Figure 1] is a diagram showing the steps involved in making the alloy test piece of the present invention.

[Figure 1]

